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ERTS DATA USER TYPE-1 PROGRESS REPORT FOR APRIL/MAY 1973

Project Title/Objective: Relevance of ERTS to the State of Ohio

Proposal Number: MMC No. 87

Contract Number: NAS5-21782

BCL Subcontract Number: 72-17/G-1793

Principal Investigator: Dr. David C. Sweet

I. DATA COLLECTION

ERTS-1 data received from NASA during the reporting period are summarized in Table I. In addition to the imagery described in the table, computer compatible tape data have also been received for most of these same scenes. Figure 1 illustrates the present status of usable repetitive ERTS imagery of the various portions of Ohio. Currently, multispectral color composites have been requested for most of the usable ERTS scenes.

Plans for study-site data collection during the next reporting period include aircraft underflights of the East Liberty, Wooster, and Ottawa study sites during favorable weather conditions as ERTS-1 passes over Ohio in June. Adverse weather conditions have prevented aircraft underflights this reporting period. To supplement the ERTS imagery and aircraft photography, field radiometric and photographic ground-truth surveys of the study sites are planned. Presently, the equipment required to obtain such ground truth data is being calibrated and standardized procedures which will govern the data collection activities are being finalized.

II. DATA ANALYSIS

The major analytical task performed during this reporting period focused on the preparation of a demonstration product describing the usefulness of ERTS data to surface mining needs in Ohio. This working paper titled "A DEMONSTRATION OF THE APPLICATION OF SATELLITE SURVEY DATA: SURFACE MINING" is

(E73-10621) RELEASE OF ERTS TO THE STATE OF OHIO Progress Report, Apr. - May 1973 (State of Ohio Dept. of Development, Columbus.) 20 p HC $3.00
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TABLE I. COVERAGE AND QUALITY OF ERTS-1 DATA OVER OHIO RECEIVED DURING THIS REPORTING PERIOD

Date	Time	Area	Quality Comments*
		TRACE 1	
3/7/73	15375	SE Ohio and West Virginia	Fair
4/12/73	15364	NE Ohio and Western Lake Erie	Fair
3/25/73	15375	SE Ohio and Kentucky	Fair
		TRACE 2	
3/8/73	15422	NE Ohio, Lake Erie, & Canada	Excellent
3/8/73	15424	Columbus and Eastern Ohio	Excellent
3/8/73	15431	SE Ohio	Excellent
3/8/73	15433	SE Ohio and Kentucky	Good
4/13/73	15422	NE Ohio, Lake Erie, and Canada	Good
4/13/73	15425	Columbus and Eastern Ohio	Fair
4/13/73	15431	SE Ohio	Poor
4/13/73	15434	SE Ohio and Kentucky	Very poor
		TRACE 3	
2/19/73	15484	Southern Ohio and Kentucky	Fair
3/9/73	15480	NW Ohio, Lake Erie, and Canada	Very poor
3/9/73	15485	SW Ohio	Very poor
3/27/73	15481	NW Ohio, Lake Erie, and Canada	Excellent
3/27/73	15483	Columbus and Western Ohio	Excellent
3/27/73	15490	SW Ohio, Indiana, and Kentucky	Excellent
4/14/73	15480	NW Ohio, Lake Erie, and Canada	Excellent
4/14/73	15483	Columbus and Western Ohio	Excellent
4/14/73	15474	SW Ohio, Indiana, and Kentucky	Excellent
		TRACE 4	
3/10/73	15541	Western Ohio and Eastern Indiana	Very poor
3/10/73	15544	SW Ohio, Indiana, and Kentucky	Fair
3/28/73	15535	NW Ohio	Very poor
4/15/73	15544	SW Ohio, Indiana, and Kentucky	Poor

* Quality relates to general cloud cover condition over area covered by satellite photography.

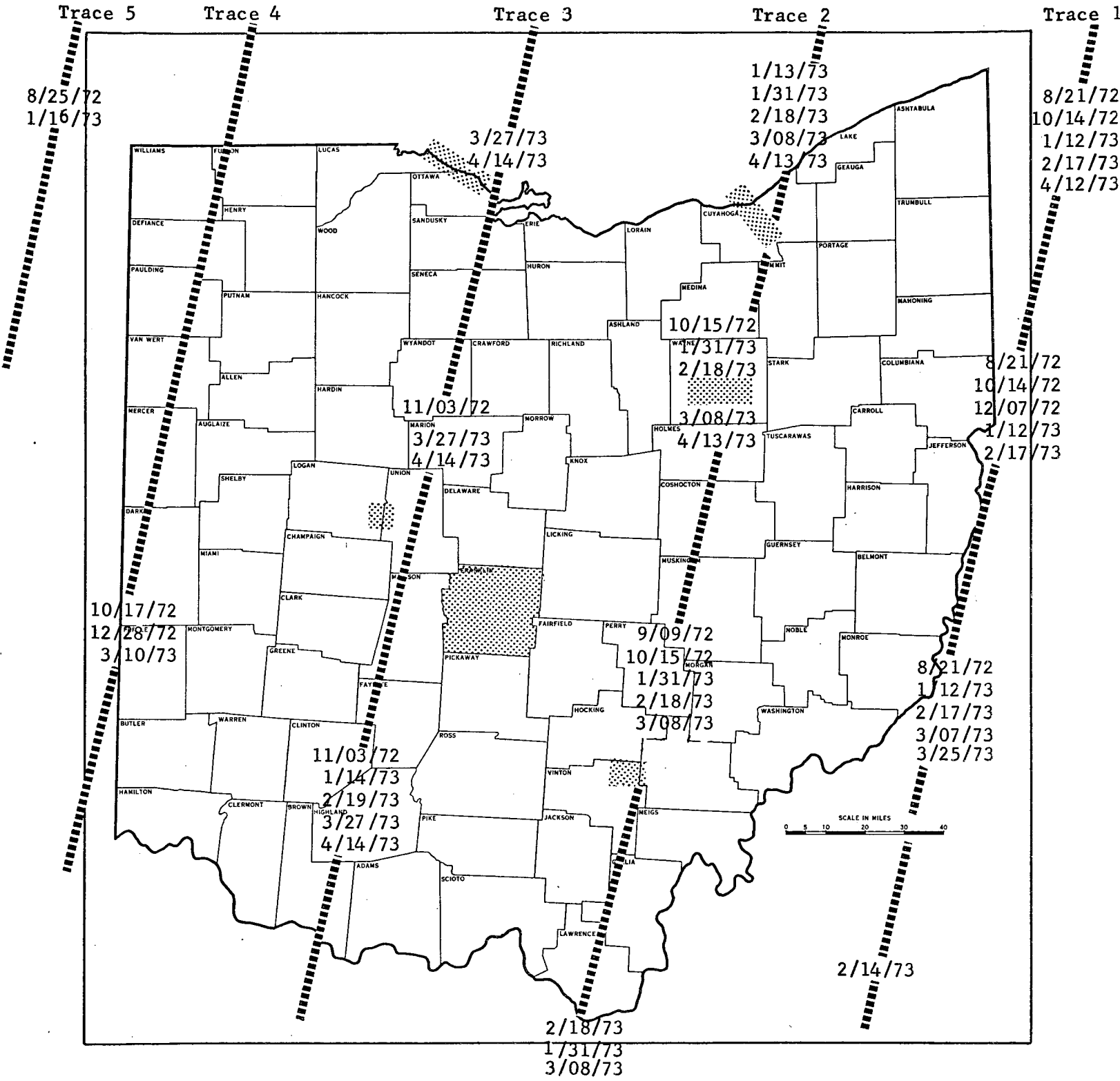


Fig. 1. Status of Usable Repetitive ERTS Imagery for Ohio.

attached as an Appendix. The paper summarizes and pictorially displays the ability of ERTS to detect and inventory surface mining activities in Ohio with emphasis on coal strip mining. Preliminary findings in evaluating ERTS imagery for monitoring reclamation/restoration soil erosion, and standing water are also summarized.

The purpose of this and subsequent demonstration products is to prepare draft reports documenting ERTS user applications identified for distribution to State officials and planners, initially for information purposes but ultimately for their evaluation of planning and legislative relevance and potential cost-saving benefits. Plans for data analysis tasks during the next reporting period include similar analysis and demonstration product preparation for land use and Lake Erie interests in Ohio.

III. DCS/DCP EFFORT

During April and May considerable effort was expended to refurbish several water quality components of the Schneider monitoring equipment which is interfaced with the DCP. This included the removal, servicing, and replacement of the raft-mounted submersible pump, and the repair or servicing of the water quality sensors. It was found that these components, ostensibly in working order at the start of the program, had in actuality deteriorated from lack of use over an extended period. One sensor, that for water conductivity, is inoperable, but will not be replaced at present because of the relatively high cost of doing so. However, lack of a sensor for this parameter is not significant to the purpose (demonstration of ERTS relay capabilities) of the DCP installation. In addition, the physical arrangement of the interface device was improved by providing a shelf mounting and a cabled set of coaxial leads with plug-and-joint connectors. This permits the selective use of the nominally 12 (now actually 11) sensors of the equipment with the 8 available channels of the DCP. The DCP has been transmitting meteorological data without interruption since February 28.

Consideration is being given to holding a one-day workshop to directly acquaint interested potential state users with the DCP installation and its capabilities.

The only problem experienced during the period has been the delay in interfacing the water quality sensors with the DCP, because of the necessary renovation discussed above. This interfacing should be accomplished in the near future, with the interfacing of available air quality sensors to follow shortly thereafter.

IV. DATA UTILITY ASSESSMENT

No detailed assessments of the utility of ERTS data were conducted during this reporting period. Instead, however, attention was given to testing the usefulness of ERTS imagery to individual programs and interests within various state agencies. This activity included visits to Battelle's Remote Sensing Applications Laboratory where state agency and Battelle personnel jointly analyzed the ERTS data in regard to a variety of state data needs. In total, over seventy-five people with varying degrees of interest in the ERTS program visited the Remote Sensing Applications Laboratory during April and May. Selected demonstration items such as 35-mm slides and color polaroid prints of enlarged ERTS imagery were made for selected individuals for subsequent review and evaluation.

V. SIGNIFICANT RESULTS

There were no significant program results this reporting period.

VI. MISCELLANEOUS

At the request of the Ohio State University, a graduate-level seminar on the analysis and application of ERTS data was given by Ohio-ERTS project staff on April 24. This was followed by a two-hour, in-the-laboratory seminar at Battelle for twenty-five students on May 21.

During the last two months serious discussions have been held relating to a possible Lake Erie study by the Ohio Environmental Protection Agency, The Ohio State University, and Battelle Columbus Laboratories in which the utilization of ERTS data will be considered. In this connection, upon request, a collection of color-enhanced ERTS scenes showing Lake Erie plumes, ice features, suspended sediments, and circulation patterns were prepared for Ohio Environmental Protection Agency personnel.

On May 16, the Battelle Remote Sensing Applications Laboratory and the Ohio ERTS/Skylab program was the subject of a electronic news conference which resulted in a four-minute local TV broadcast.

In an effort to inform the Office of Management and Budget of Ohio's interest in satellite survey opportunities and concern regarding recent ERTS/Skylab funding decisions, a letter was prepared by Governor John J. Gilligan and sent to Director Roy Ash of that office. A copy of this letter is attached to this report.

As a result of several meetings with Ohio Biological Survey representatives during April, the following cooperative tentative commitments were made:

1) Battelle would furnish to the Survey copies of selected imagery appropriate to the Central Ohio study, a copy of their instruction booklet concerning the interpretation of ERTS imagery, and personal assistance concerning the use and interpretation of the imagery;

2) the Survey would furnish to Battelle access to its subproject reports and the base data they contain, and technical insight concerning the interpretation of ERTS imagery as it relates to the various area specialties of the Survey's subcontractors.

Also, during this reporting period a state-agency request for an 1:250,000 enlargement of Clark County, Ohio and surrounding areas from ERTS-1 imagery was filled.

1

STATE OF OHIO
OFFICE OF THE GOVERNOR
COLUMBUS 43215

JOHN J. GILLIGAN
GOVERNOR

April 9, 1973

Mr. Roy Ash, Director
Office of Management and Budget
Executive Office Building
Washington, D.C. 20503

Dear Mr. Ash:

It has long been hoped that the results of space endeavors would become more directly useful to problem-solving in the public sector. Although several of NASA's application programs (viz., communications and meteorological satellites) have accomplished some such benefits, NASA's Earth Resources Technology Satellite (ERTS) program represents the first major opportunity for this hope to be realized at the state and local government levels.

Initial evaluations of multi-agency relevance of ERTS-1 data to resource management interests in Ohio under the leadership of Dr. David Sweet, Director, Department of Economic and Community Development, are quite promising. Specifically, we anticipate real benefits to be obtainable from even the experimental data currently being acquired to such priority Ohio planning and regulatory activities as strip mine inventorying and reclamation monitoring, environmental quality protection, and state-wide land use planning. Accordingly, we are concerned about recent funding decisions adversely affecting NASA's space applications programs, particularly those involving ERTS and Skylab (EREP) programs. We feel that further consideration should be given to ensuring that sufficient funds are provided to support continuing and viable programs in this area.

We in Ohio hope that our experience will help in shaping an OMB funding rationale which will enhance technology transfer and utilization in state and local government program operations.

Sincerely,

JOHN J. GILLIGAN
Governor

JJG/TLW/jh

A DEMONSTRATION OF THE APPLICATION OF SATELLITE SURVEY DATA: SURFACE MINING

by

George E. Wukelic, Joachim G. Stephan, and Thomas F. Ebbert

May 15, 1973

NOTICE: This document contains information of a preliminary nature and was prepared primarily to demonstrate ERTS data utility for assessment by State of Ohio planning and resource management personnel. It is subject to revision and correction and therefore does not represent a final report.

SATELLITES FOR OHIO'S FUTURE

"The Ohio satellite effort is a major step toward wise management necessary for balanced development in Ohio".

Dr. David C. Sweet, Director
Ohio Department of Economic and
Community Development

Battelle Columbus Laboratories is currently working with the State of Ohio to evaluate imagery obtained by NASA's first Earth Resources Technology Satellite (ERTS-1). This satellite passes over Ohio every 18 days, photographing its surface with four "cameras", each time covering roughly a 10,000 square nautical mile area. These photographs are analyzed by Battelle researchers in concert with State of Ohio resource planners and managers to determine what useful environmental, natural, and cultural resource information can be obtained and its significance to the State's on-going environmental planning, monitoring, and enforcement activities.

Ohio is one of the few states making a comprehensive multidisciplined assessment of the state-level utility of orbital survey data. Participating state agencies are:

- Department of Economic and Community Development (Lead Agency)
- Department of Natural Resources
- Environmental Protection Agency
- Department of Transportation
- Public Works
- Department of Health
- The Ohio State University.

The most significant program result to date has been the swiftness with which remote sensing from space has captured the interest and confidence of potential state and local user groups, in spite of their limited experience in the application of remote sensing technology.

This publication is one of several describing and demonstrating the application of orbital survey data to major state-level environmental and resource management problems.

BACKGROUND

Currently Ohio is considering the need for legislation to regulate all surface mining activities throughout the state. In April 1972, responding to overwhelming public sentiment, the Ohio Legislature passed a bill placing very stringent controls on strip mining in the state. This law places many new reclamation requirements on the operator, requires extensive preplanning of strip-mine operations, and gives the state power to deny licenses to strip mine under certain conditions. The implementations of this law is a tremendous task which

has not been totally achieved. To date, 282,632 acres of Ohio land have been stripped for the mining of coal alone, according to the Ohio Department of Natural Resources. Of these, 192,198 acres have been reported as reclaimed. The U. S. Bureau of Mines reports that in 1970, Ohio surface mined more than 37 million tons, placing it in second place in the nation only behind Kentucky. In addition, more than 46 million tons of limestone and more than 41 million tons of sand and gravel were also mined according to the Ohio Division of Mines.

Thus, the ability to detect, monitor, and inventory surface mining and surface mine reclamation efforts constitutes an urgent and immediate need in the State of Ohio. Until now this had to be accomplished through painstaking ground surveys and/or relatively expensive air surveys.

As soon as ERTS imagery became available in October, 1972, it became obvious that the satellite's multiband imagery would be most useful for the detection and inventory of surface mine areas as well as areas formerly strip mined and now undergoing reclamation. Since each photograph covers 100 x 100 nautical miles (or 10,000 square nautical miles) the 23 Ohio counties in which strip mining is taking place are more than covered by four photographs. And since the satellite passes over Ohio every 18 days, information about significant changes may be monitored on a year-round basis.

What is Surface Mining?

Surface mining is the process of removing the so-called "overburden" consisting of vegetation, soil, and rocks from the underlying resource.

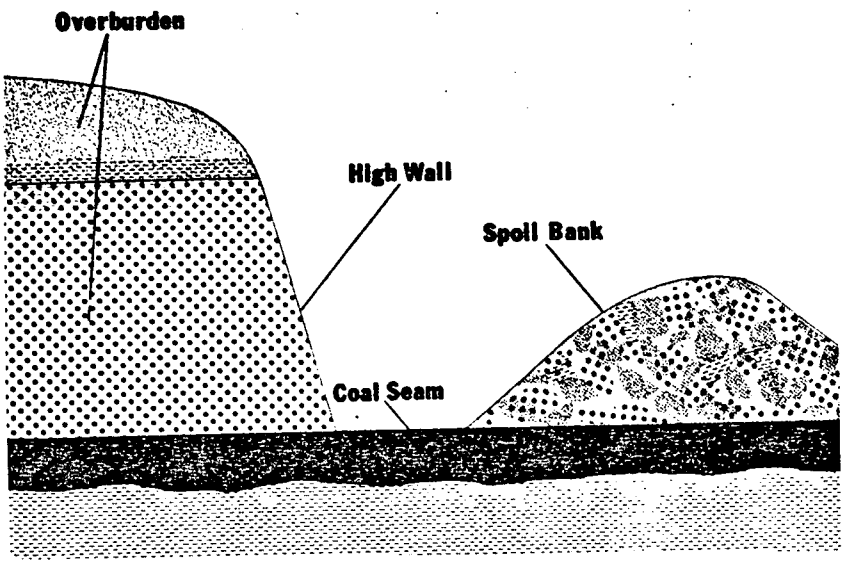
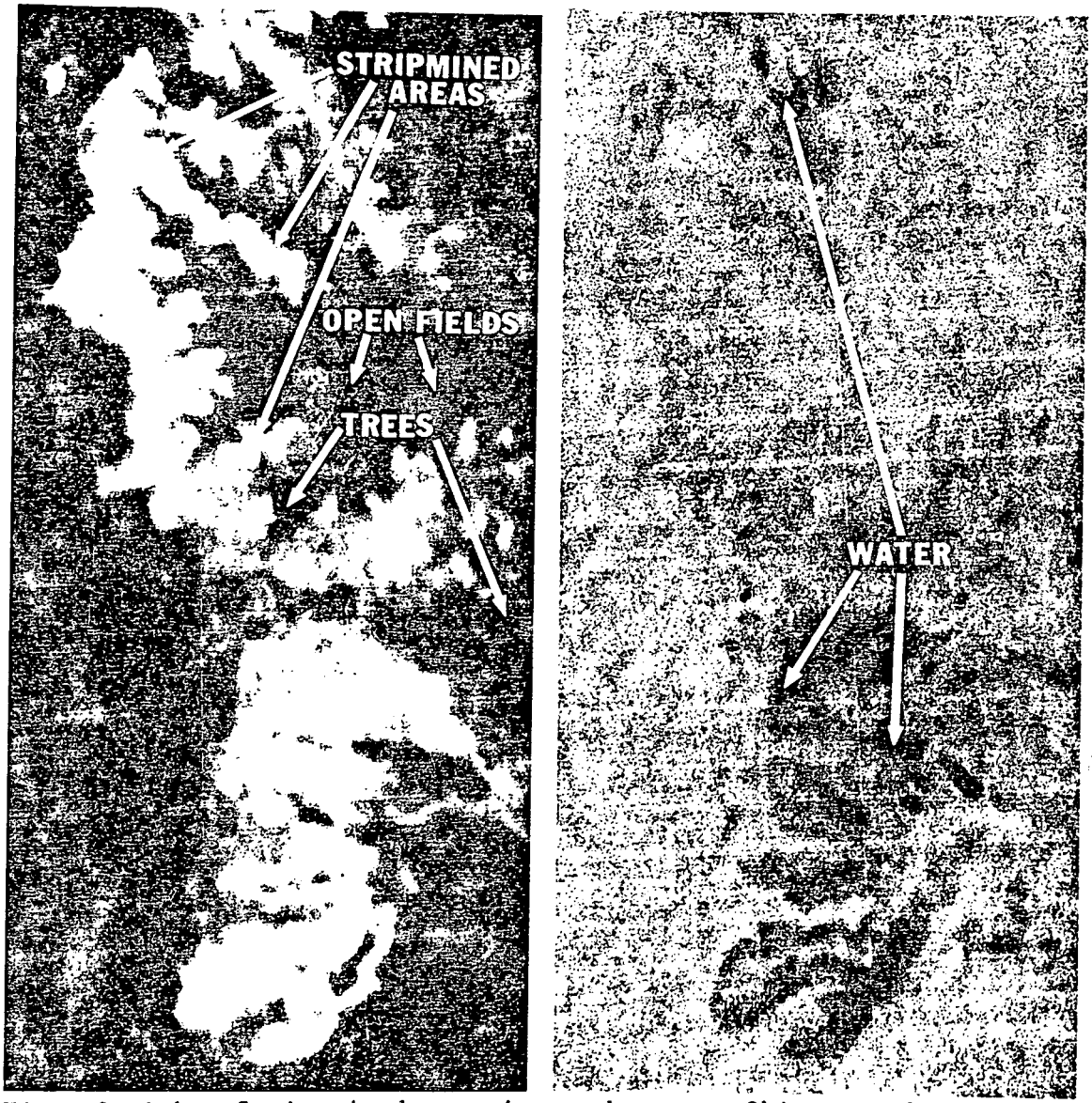


Fig. 1 depicts a typical cross section of a coal strip mine with the original vegetation, and the adjacent sandstone highwall, spoil bank, and coal seam.

Fig. 1.

How Does ERTS Detect Surface Mining?

Radiometric measurements have been made of these man-made features in Southeast Ohio which revealed that in the visible portions of the electromagnetic spectrum (4,000-7,000 Å), the high wall and spoil bank material reflect solar energy 3-4 times as much than the surrounding original vegetation. In the near infrared band, however, vegetation reflects sunlight more effectively. The result of this phenomena may be observed in Figures 2a & b, which show a strip mine in Southeast Ohio of some 8 miles in length and 1/2 to 1 mile wide. A cursory examination will immediately reveal that in ERTS Band Number 5 (6,000-7,000 Å) strip mining appears most prominent, whereas in Band Number 7 (8,000-11,000 Å) bodies of water appear more prominent (very dark) because infrared radiation is readily absorbed in the first few layers of water. ERTS multiband photography thus provides a means for the detection and interpretation not possible through broad band photography.



Figs. 2a & b. Strip-mined area in southeastern Ohio recorded by ERTS in Band Number 5 (visible spectrum) and Band Number 7 (near infrared spectrum) (August 21, 1972). Band Number 5 shows strip-mined areas most vividly, whereas Band Number 7 is useful for showing standing bodies of water within strip-mined areas.

STRIP-MINE DETECTION

A brief examination of the ERTS photograph (Fig. 3) shows how readily strip-mine features may be detected in typical mid-western terrain during the growing season. Repeated analysis of ERTS imagery has resulted in the successful identification of strip-mine features as small as 2-3 acres. The area shown here was recorded by the satellite's multiband scanner system on August 21, 1972, in the Barnesville, Ohio, area. This is the general area where the world's largest shovel, the Gem of Egypt, is operating.

To illustrate the degree of image detail and area fidelity possible with ERTS photography, a relatively small area of strip-mine land of approximately nine square miles was magnified more than 140 times from the original ERTS 70-mm negative (see area in square). This greatly magnified image was then compared to a standard USGS topographic mapsheet and a corresponding aerial photograph taken in May, 1972 (map and photo scale 1:24,000).

Figures 4a-f show a comparison of these various data. It may be readily seen that through magnification and electronic enhancement the original ERTS imagery, sufficient image detail and area fidelity may be extracted for the detection of strip-mining activities in the State of Ohio and terrain comparable to Ohio.

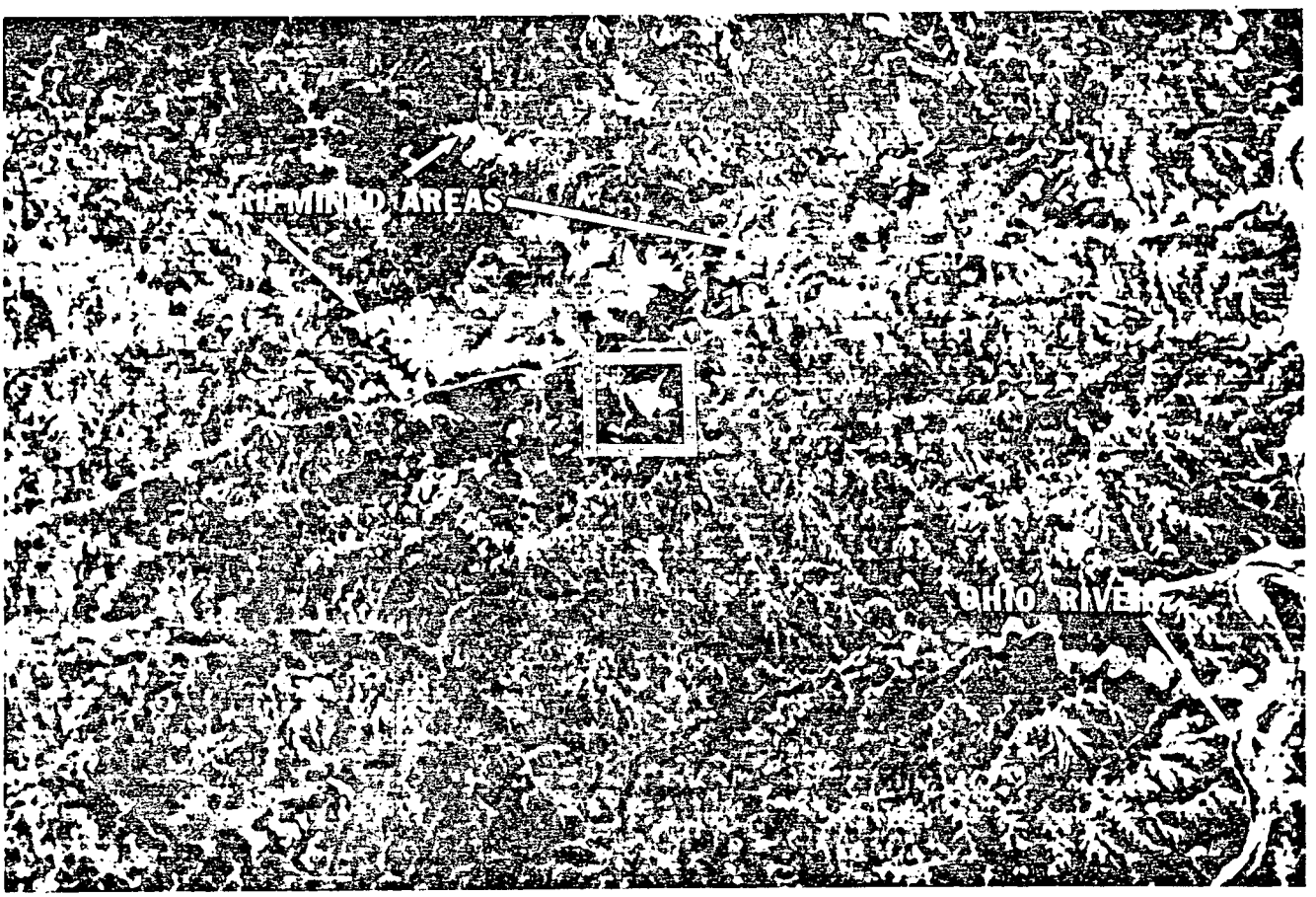


Fig. 3. Heavily strip-mined area in eastern Ohio, showing portions of Belmont, Guernsy, and Noble Counties (August 21, 1972).

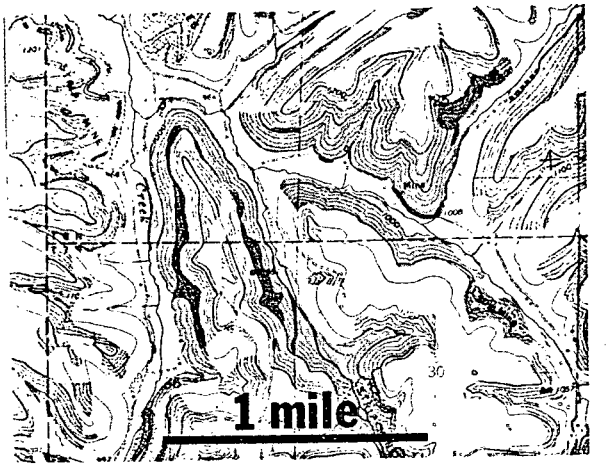


Fig. 4a. 1:24,000 USGS topographic map sheet (reduced by 1/2 original format).

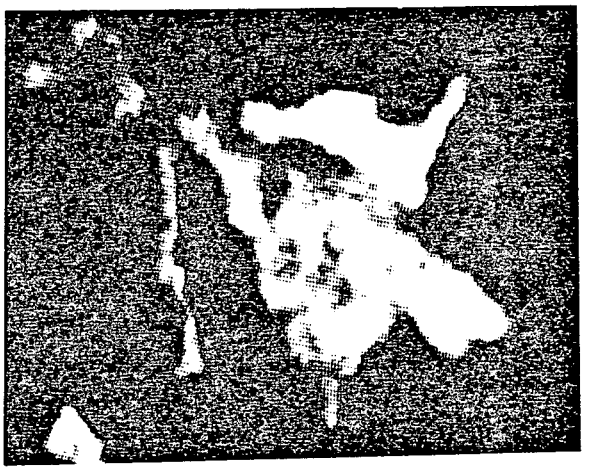


Fig. 4b. Enlarged ERTS photo showing strip mine within square of Fig. 3 (visible spectrum). Stripped areas appear very light. Relatively undisturbed areas appear grey to black. The ERTS imagery taken in August, 1972, also shows additional strip mining in this area not visible in the aircraft photograph taken four months earlier (May, 1972).

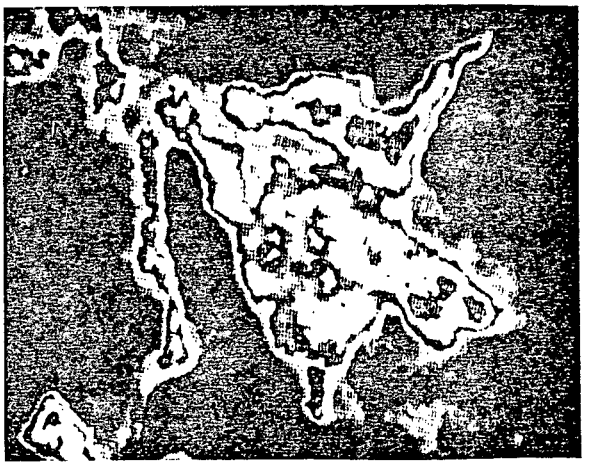


Fig. 4c. Electronically enhanced ERTS photo as seen in Fig. 4b. A density "slicing" viewer (shown in Fig. 9b) was used to distinguish several grey levels in the photo. This technique is useful to distinguish the high wall, spoilbanks, and original vegetation in the strip-mine area.

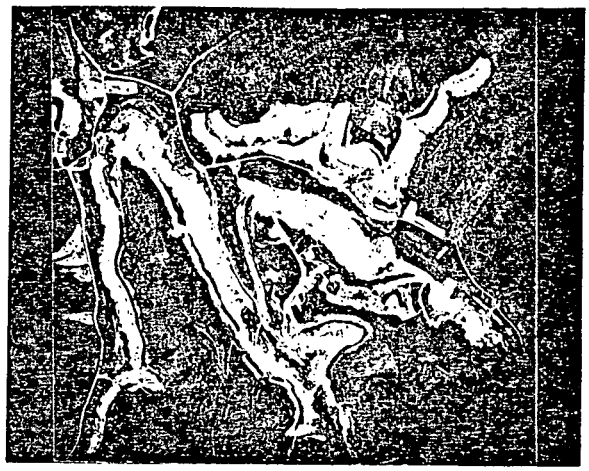


Fig. 4d. 1:24,000 aircraft picture of strip mine within the square of Fig. 3. Photos such as these are used to show that ERTS imagery has sufficient image quality and area fidelity to perform strip-mine inventories (photo by NASA Lewis Research Center).

Fig. 4e. Enlarged ERTS photo of strip mine of square within Fig. 3 (infrared spectrum). The two infrared bands are particularly useful for determining standing bodies of water in strip-mine area.

Fig. 4f. Electronically enhanced image shown in Fig. 4e. Note similarity to aircraft photo in 4d.

STRIP-MINE INVENTORIES

ERTS data are expected to be useful in implementing Ohio's strip-mine law. Initially there is a need for inventorying and mapping all strip-mined land to support reclamation planning activities, as an accurate and recent inventory in a readily available form does not exist. Information is especially scanty on strip-mined land before 1948, when Ohio passed its first strip-mine legislation.

With the ability to identify strip-mine features with ERTS imagery well established, it can now be shown that the satellite data may be used to provide inventories of entire counties. Harrison County in Eastern Ohio, for example, covers some 245,000 acres. According to data from the Ohio Department of Natural Resources, there are some 17,603 acres of strip-mine land which still remains unreclaimed.

With the aid of an image enhancement viewer with built-in planimeter the effort was undertaken to demonstrate that (1) the unreclaimed strip-mine areas could be enhanced to the exclusion of any other terrain feature using ERTS imagery, and (2) that an accurate area calculation was possible in a relatively short period of time.

Figure 5a shows a topographic map of Harrison County; Figure 5b shows an electronically enhanced image of those areas still awaiting reclamation. Table 1 lists the results.

Area calculation achieved in this survey corresponds quite favorably to Department of Natural Resources data. Actually, the lower figures achieved in this evaluation are due to the fact that Harrison County has strip mines which have been re-effected several times, i.e., the same areas have been mined more than ones resulting in a higher acreage count.

Thus, it appears that the careful analysis of ERTS data results in more accurate acreage inventories than heretofore possible through more conventional means.

TABLE 1

COMPARISON OF STRIP-MINE AREA ESTIMATES FOR HARRISON COUNTY, OHIO

Total Land Area -- 258,000 Acres

	ODNR	ERTS-1
% of strip-mined land	19.01	18.4
Area affected	49,064 acres	47,472 acres
% of unreclaimed strip-mined land	6.8	6.2
Area unreclaimed	17,603 acres	15,996 acres

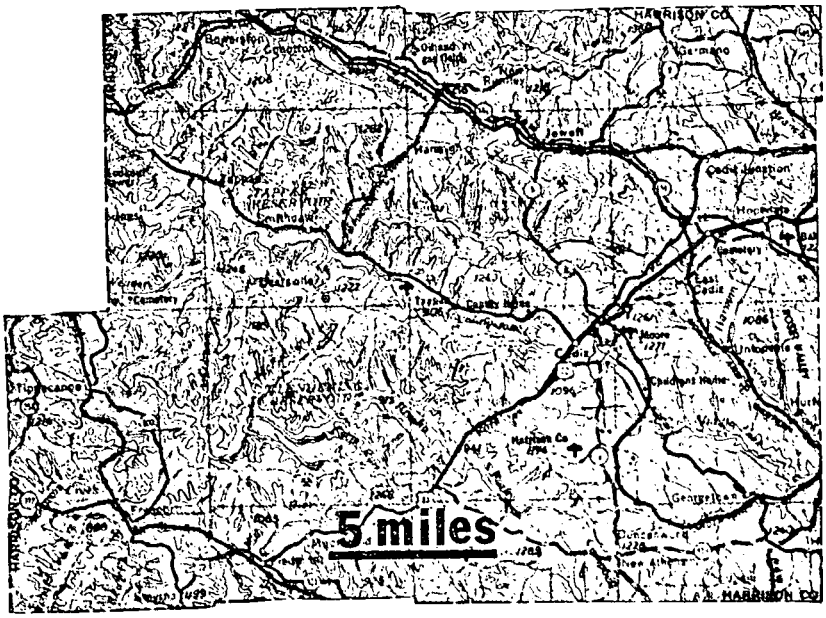


Fig. 5a. Reduced copy of 1:250,000 topographic map showing Harrison County.

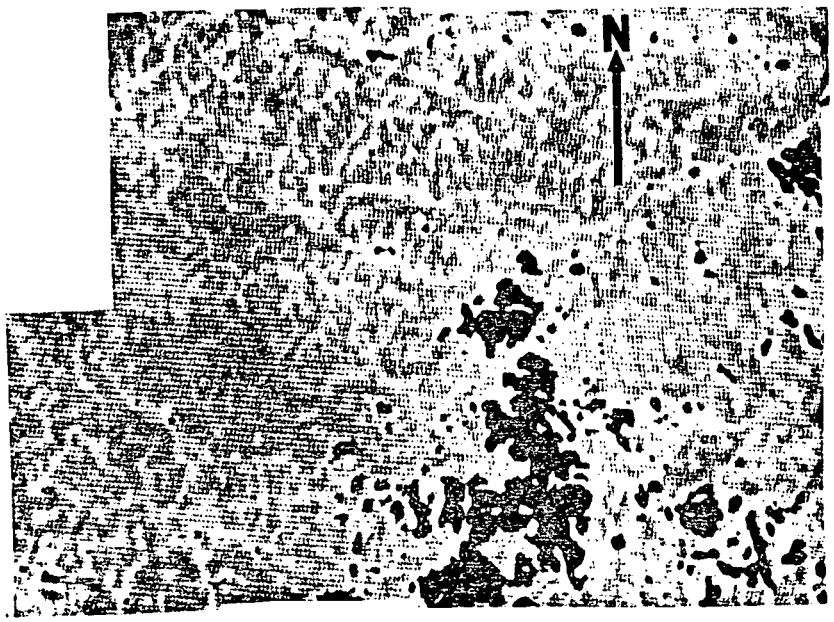


Fig. 5b. Enhanced display of ERTS-1 photo showing unreclaimed strip-mine areas in Harrison County (strip-mine areas are in black) (August 21, 1972).

STRIP-MINE RECLAMATION

State of Ohio planners need to have accurate data about areas of strip mining under reclamation. Primarily, the success of short- and long-term reclamation efforts must be known. Battelle's researchers are currently evaluating the accuracy with which strip-mining reclamation may be assessed. Figure 6 shows an example of a small strip-mine area near Zaleski, Ohio, which appears in the very initial stages of reclamation. Using repetitive ERTS coverage, the degree of successful reclamation will be monitored by the vigor of the vegetation planted earlier over levelled spoil banks. The extent to which soil erosion and standing water can be determined in these areas is currently also under assessment. Ecological impacts, for example, acid mine draining effects of strip-mining activities, are being investigated by other ERTS investigators.

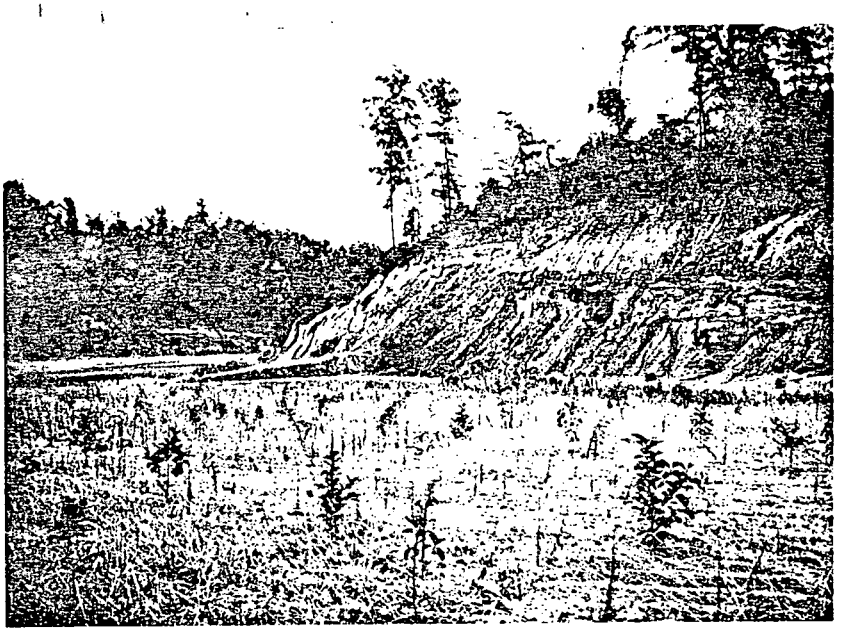


Fig. 6. Strip-mine area in Zaleski State Forest, southeastern Ohio, showing recent reclamation effort.

OTHER SURFACE MINING

As already indicated, the mining of gravel, sand, and limestone exceeds that mining of coal in the State of Ohio. Figure 7 shows the Marble Cliff quarries in Columbus, Ohio. This photo was taken by ERTS-1 over Central Ohio on October 15, 1972. As in the detection of coal strip mines, the presence of this particular surface mine is due to the differential reflections of the resource material (limestone) and the surrounding vegetation. Currently a matrix is being established which relates the size and types of surface mines that can be determined in Ohio and areas typical of Ohio.

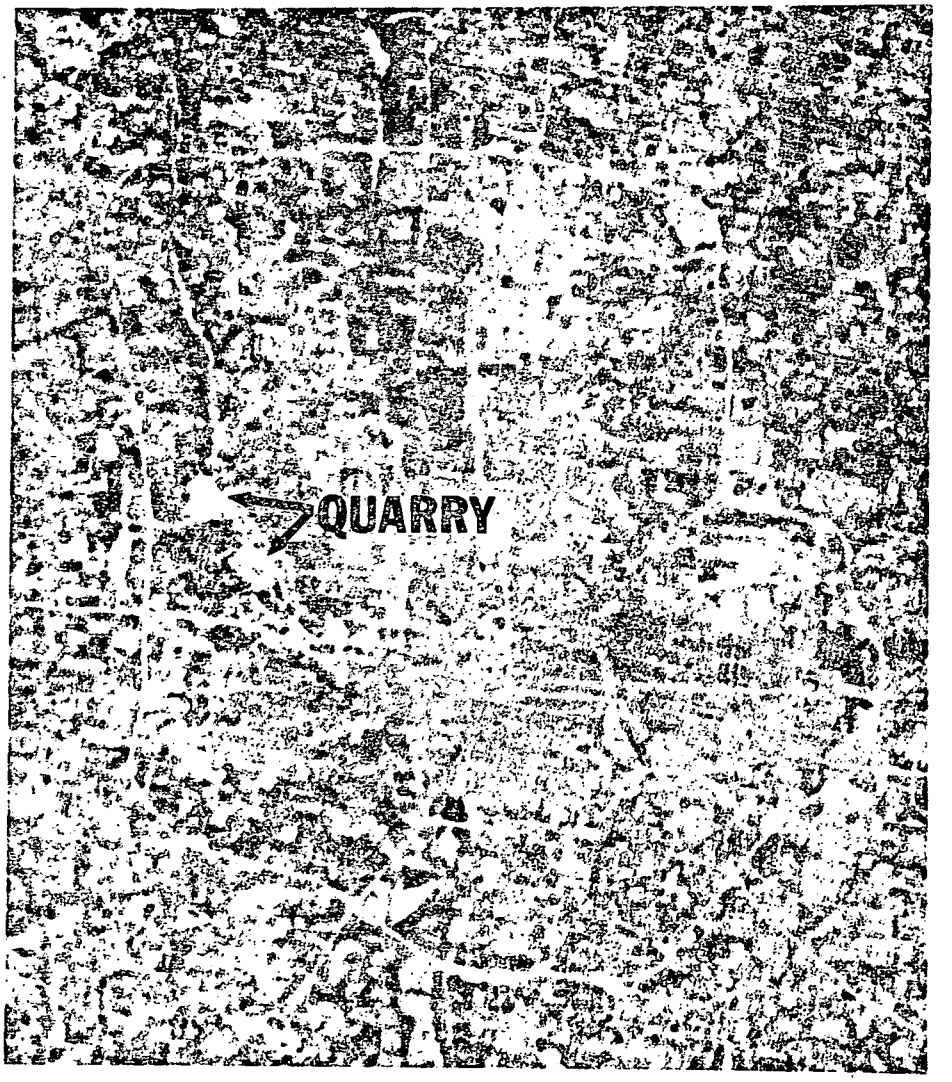


Fig. 7. ERTS-1 photo of Columbus, Ohio, with Marble Cliff Quarry, October 15, 1972. (Scale 1:250,000)

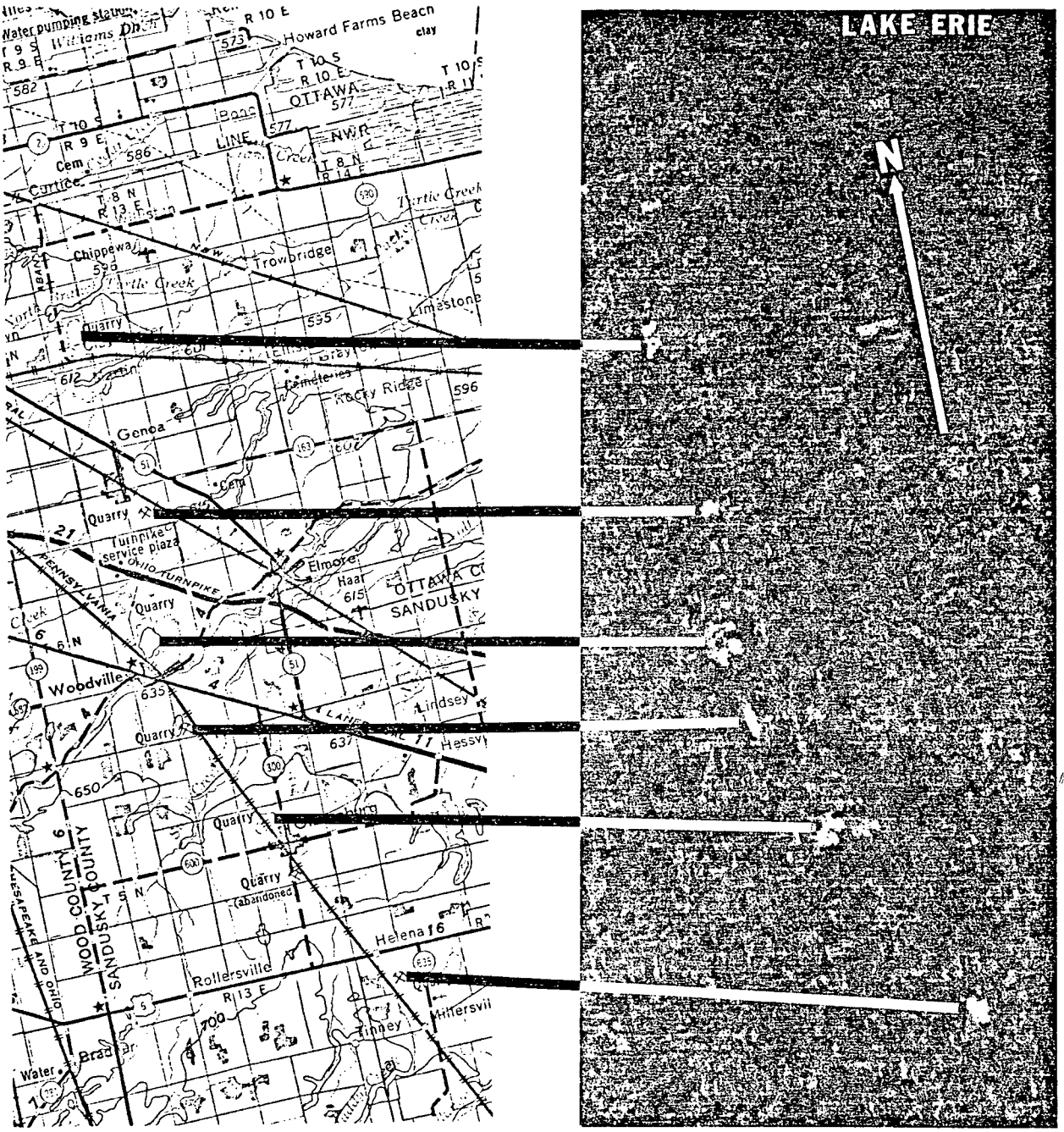


Fig. 8. Topographic map sheets and ERTS-1 photo showing location of surface mines, March 27, 1973. (Scale 1:250,000)

REMOTE SENSING AT BATTELLE COLUMBUS LABORATORIES

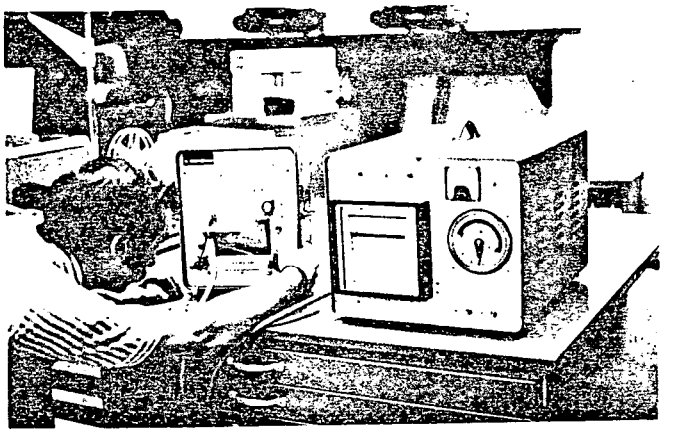


Fig. 9a. ISCO Spatial radiometer used for spectral "signature" collection in the field.

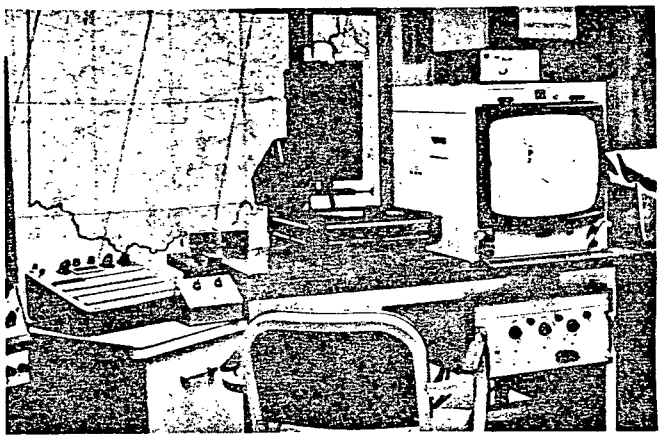


Fig. 9b. Density slicing and color encoding analysis system.

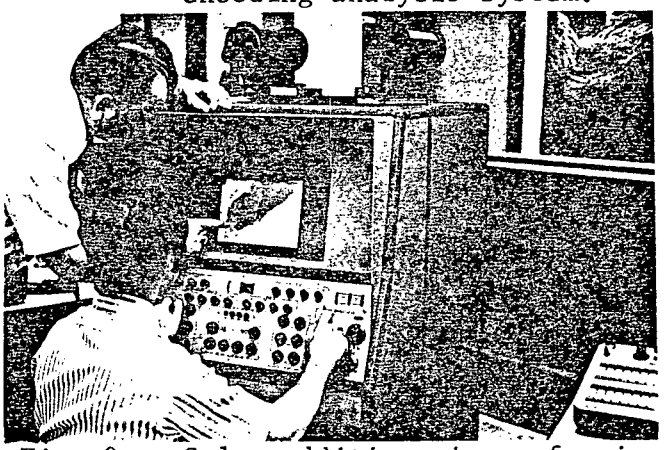


Fig. 9c. Color additive viewer for image enhancement and comparison.

Battelle's Remote Sensing Applications Laboratory was established in direct response to increasing requirements for the effective and timely acquisition and analysis of remotely-sensed data in a number of disciplines and applications areas principally involving:

- Environmental Quality
- Agriculture
- Forestry
- Geography/Land Use
- Transportation
- Ecology.

The most prominent application of the laboratory has been to evaluate satellite imagery for its utility to the management of natural and cultural resources in the State of Ohio, involving an area of 40,000 square miles.

The laboratory is equipped with state-of-the-art image acquisition and analysis devices to perform in-depth research involving all aspects of remote sensing, with emphasis on multiband imagery.

One of the most important aspects of the laboratory which originally governed its design is its accessibility and visibility to a wide spectrum of researchers and planners within and outside the state. The equipment and analysis procedures have been chosen to permit users with little or no experience in remote sensing to gain appreciation and confidence for applying this new tool in their research and decision making functions.